

# The role of auscultation and ultrasonography together in confirming the placement of the endotracheal intubation tube

Confirming the placement of the endotracheal intubation tube

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## Abstract

**Aim:** The usability of ultrasonography in emergency services has increased in recent years, and this study investigated the effectiveness and usability of ultrasonography in confirming the endotracheal tube location in intubations performed in the emergency department.

**Material and Methods:** It is a randomized controlled prospective study conducted in Istanbul Bakırköy Dr. Sadi Konuk Training and Research Hospital Emergency Department between 15.07.2015 and 15.10.2015. Patients over 18 years of age, without trauma and head and neck deformity were included in the study. Auscultation procedure was used to confirm the intubation site in one group of patients, and bedside ultrasonography (USG) along with auscultation (transtracheal passage through the larynx and lung sliding movements were evaluated during intubation) in the other group. End-Tidal CO<sub>2</sub> was used as the gold standard for the intubation verification method.

**Results:** A total of 130 patients, 60 (46.2%) women, 70 (53.8%) men, and a mean age of 69.0±17.8 years, were included in the study. While the Sensitivity, Specificity, Positive Predictive Value (PPV) and Negative Predictive Value (NPV) were found to be 100% in 64 patients who underwent auscultation, in 66 patients who underwent bedside USG, the sensitivity of USG was 98.3%, the specificity was 66.7%, PPV was 96.7%, NPV was 80%. Specificity, PPV and NPV increased to 100% in the same group that underwent bedside USG with auscultation. There was no statistical difference between USG and auscultation in confirming the intubation site ( $p>0.05$ ).

**Discussion:** Bedside USG, which is used together with auscultation, is a method that has high sensitivity and specificity in confirming tube location in emergency departments, is inexpensive, radiation-free, can be used at the bedside, can be repeated, and can detect tube location errors early.

## Keywords

Emergency Department, Intubation, Bedside Ultrasonografiography

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## Introduction

Airway management skills are indispensable tools for all treatment procedures and tools of the emergency physician [1]. The goals of airway management are oxygenation and ventilation. Achieving these goals may be as easy as repositioning the patient's head, or may be complicated enough to require a surgical airway. Ensuring airway integrity, oxygenation, ventilation and prevention of aspiration are the mainstays of emergency airway management [2]. Indications for tracheal intubation in AS include correction of hypoxia or hypercarbia, prevention of hypoventilation that may develop, and making sure that the patient's airway is open. Secondary indications are the preparation of the necessary route for resuscitation and diagnostic includes the paralysis that will occur during the studies [3].

Rapid-sequence intubation (RSI) is the facilitation of endotracheal intubation with the simultaneous administration of induction and neuromuscular blocking agents [4]. Endotracheal intubation is the safest way to ensure that the patient's airway provides oxygenation and ventilation and prevents aspiration. Clinical evaluation of oxygenation and ventilation alone in chaotic AS may be unreliable. Pulse oximetry and capnography are helpful guides in the decision for tracheal intubation [5].

If the patient cannot protect the airway, the risk of aspiration increases. The role of the gag reflex in airway preservation is unclear. The gag reflex could not be demonstrated in up to 37% of healthy volunteers [6]. In patients without spontaneous swallowing, the airway is compromised and they are at risk for aspiration and may require urgent intervention [6].

The most basic way to ensure emergency airway safety is endotracheal intubation. Inadvertent esophageal intubations during the procedure are rare, but they have a serious impact on morbidity and mortality [7]. The rate of esophageal intubation was found to be 6-16%. Early recognition of esophageal intubation is very important during resuscitation [8]. Although there are many methods for confirming tube location, there is no completely reliable method [8]. All these applications have limitations, but studies have shown that quantitative capnography is the most reliable and specific method [8]. Ultrasonography (USG) is a common examination in emergency rooms and intensive care units. USG is useful in airway management because of its low cost and portability. In this study, promising results were obtained in confirming the ETT site with the use of USG [9].

The aim of this study is to determine the usability of ultrasonography in confirming endotracheal tube location in patients intubated in the emergency department.

## Material and Methods

This study is a prospective randomized study and was conducted in Bakırköy Dr. Sadi Konuk Training and Research Hospital (BEAH), Emergency Medicine Clinic between 15.07.2015 and 15.10.2015.

Ethics committee approval for the study was obtained from Bakırköy Dr. Sadi Konuk Training and Research Hospital Ethics Committee. The study was carried out in accordance with the principles of the World Medical Association Declaration of Helsinki.

## Inclusion criteria

Patients who applied to the emergency department for a period of three months and were intubated for medical reasons or were to be intubated due to arrest were included in the study.

## Exclusion criteria

Patients under the age of 18, patients who had a trauma-related arrest, who needed intubation in the emergency department, who had tracheostomy, who had head and neck deformities, or who had anatomical deformities, were not included in the study.

## Patient selection

Our study was conducted between 15 July 2015 and 15 October 2015; 130 patients with intubation indication in the Sadi Konuk Training and Research Hospital Emergency Medicine Clinic were included. While Oscultation-Capnography was applied to patients corresponding to odd numbers, USG-Ascultation-Capnography was applied to patients corresponding to even numbers, and tube location was verified in intubation. Data from both groups were discussed in the conclusion and discussion section.

## Ultrasonographic evaluation method

As criteria for confirming the location of the tube with USG, the passage movement of the tube and the movements of the ventilated lung are based on sonographic observation. Transition movement of the tube was evaluated by passing the tube through the trachea or esophagus with a linear ultrasonography probe placed transversely over the suprasternal notch. The movement of the ventilated lung was evaluated by looking at the sliding movements in the lung according to the BLUE protocol. General Electric brand Vivid e model and 10 MHz linear probe were used as ultrasonography device.

## Implementation of the transaction

The location of the endotracheal tube was evaluated by ultrasonography by the research assistants working in our clinic in the last year.

Patients' complaints at the time of admission to the emergency department, demographic data, blood pressure, oxygen saturation, comorbid diseases, and Mallampati scores determined by the intubation doctor were recorded.

Intubations of patients were performed by the most senior resident doctors in the emergency department and immediately gave their own feedback to the investigator on the correctness of tube location.

All patients were followed up capnographically after and during intubation.

## Statistical analysis

Statistical analyzes were performed using SPSS 16.0 for Windows. Descriptive criteria were presented as mean and percentage distribution. Statistical significance level was accepted as  $p < 0.05$ . The conformity of the data to the normal distribution was checked with the Kolmogorov-Smirnov test. Student's t-test was used to determine mean differences between groups, and Pearson's Chi-Square test was used to compare percentile differences.

## Ethical Approval

Ethics Committee approval for the study was obtained.

## Results

The study was conducted in BEAH emergency department

between 15.07.2015 and 15.10.2015, and a total of 130 patients were included in the study. Patients who were admitted and intubated due to trauma and patients under 18 years of age were not included in the study. Twenty-seven (20.8%) patients were evaluated as arrest and emergency intubation was performed, while 11 (8.5%) patients were intubated due to hypoxia and 92 (70.8%) patients were intubated for airway safety.

Of the 130 patients included in the study, 60 (46.2%) were female and 70 (53.8%) were male. The mean age of the patients was 69.0±17.8 (Table 1).

The mean age of the auscultation group was 73.9±14.4, and the mean age of the USG group was 64.3±19.5. The mean age of all intubated patients was 69.0±17.8 years.

In the group without USG, there were 30 (46.9%) females and 34 (53.1%) males, a total of 64 individuals. There were 30 (45.5%) women and 36 (54.5%) men, totally 66 people in the USG group.

The 27 patients who were intubated were considered as arrest. Fifty-three (40.8%) patients had general condition disorder, 34 (26.2%) had shortness of breath, 21 (16.2%) had unconsciousness, 10 (7.7%) had intoxication, 9 (6.9%) had syncope, 2 (1.5%) had chest pain and 1 (0.8%) patient had abdominal pain.

Among the intubated patients, in the Auscultation-Capnography group 28 (43.8%) patients had general condition disorder, 15 (23.4%) had dyspnea, 13 (20.3%) had impaired consciousness, 1 (1.6%) had chest pain, 2 (3.1%) patients had intoxication, 4 (6.3%) patients had syncope, 1 (1.6%) patients had abdominal. Patients in the group who underwent USG-Auscultation-Capnography, 25 (37.9%) had general condition disorder, 19 (28.8%) had shortness of breath, 8 (12.1%) had impaired consciousness, 1 (1.5%) had chest pain, 8 (12.1%) had intoxication, 5 (7.6%) patients had syncope, and no significant difference was found between the reasons for admission in both groups (p=0.368).

Vital values such as pulse, blood pressure, and saturation were not measured and were not included in the study in patients admitted with arrest and intubated.

**Table 1.** Distribution of groups by age and gender.

	Group without USG (n= 64)	USG group (n= 66)	Total (N=130)	P value
Age (Ort±SD)	73,9±14,4	64,3±19,5	69,0±17,8	0,002
Gender				
Female	30 (46,9)	30 (45,5)	60 (46,2)	0,871
Male	34 (53,1)	36 (54,5)	70 (53,8)	

**Table 2.** Demographic characteristics of patients.

	Auscultation –Capnography Association (n=64)	USG – Auscultation – Capnography Association (n=66)	Total (n= 130)	P value
GCS	5,7±2,8	6,3±2,9	6,0±2,8	0,3
Mallampati	2,97±0,59	2,73±0,57	2,85±0,59	0,019
Systolic Blood pressure (mmHg)	113,7±36,4	109,3±35,4	111,4±35,7	0,53
Diastolic Blood pressure (mmHg)	66,5±21,9	65,3±21,7	65,8±21,7	0,78
Pulse	107,3±21,9	105,3±24,6	106,2±23,3	0,659
Saturation (%)	80,2±10,3	82,1±12,3	81,2±11,4	0,393
Arrest	16 (25%)	11 (16,7%)	27 (20,8%)	0,283

The mean Mallampati Score of the patients was 2.85±0.59. There was a difference between the two groups in mean age and Mallampati scores (p< 0.05). The mean heart rate of the patients who were intubated was 106.2±23.3/min. The heart rate was not significantly different between the two groups. The mean saturation value of the patients was determined as 81.2±11.4. Of the patients who presented with arrest, 16 were in the group without USG and 11 were in the group with USG (Table 2).

Eleven (8.5%) of 130 intubation procedures were considered gastric intubation. In our study, capnograph was considered the gold standard in confirming the tube location. While intubation performed in 5 patients in the auscultation-Capnography combination was considered as wrong intubation, intubation in 6 patients in the USG-Oscultation-Capnography combination was evaluated as wrong. No significant difference was observed in terms of false intubation rates in both groups.

In the first group, a total of 64 patients were evaluated with the combination of auscultation and capnography. While 59 of the intubations were performed correctly, 5 of them were detected as wrong intubation and re-intubation was performed. In this group, correct intubation was detected in 59 patients, similar to the auscultation procedure data, in patients who underwent capnography, while it was evaluated as incorrect intubation in 5 patients.

In the second group, 66 patients were evaluated in the group that underwent USG-Auscultation-Capnography. USG evaluated 61 of them as correct intubation and 5 as wrong intubation. In this group, in patients who underwent capnography, different from the USG data, correct intubation was detected in 60 patients, and incorrect intubation was detected in 6 patients.

In this study, the tube was withdrawn and re-intubation was performed with the suspicion of esophageal intubation by USG during the intubation procedure in 2 patients. Afterwards, re-intubation was performed and the ETT was placed in the trachea.

A total of 130 patients were evaluated in both groups, and wrong intubation was detected in 11 of 130 patients in total. While 5 of the wrong intubations were in the Auscultation-Capnography group, the number of wrong intubations was 6 in the USG-Auscultation-Capnography group.

In patients in the first group, Sensitivity was 100% (95% CI = 96.95-100%), Specificity was 100% (95% CI = 71.51-100%), in tube location verification of gastric auscultation alone, PPV was 100% (96.95-100), NPV was 100% (71.51-100). In this group, 59 correct intubations were detected by the auscultation method, while 5 intubations were evaluated as incorrect.

In the first group, in the tube location verification of auscultation alone, Sensitivity was 100%, Specificity was 100%, PPV was 100%, NPV was 100% in the presence of air in the 4 quadrants of the lung. In this group, 59 correct intubations were detected by the auscultation method, while 5 intubations were evaluated as incorrect.

Of the 130 patients in both groups who underwent gastric auscultation and lung auscultation, correct intubation was found in 119 patients in both views, while incorrect intubation was found in 11 patients.

In the second group, true positive results were detected in 59 patients in the confirmation of tube location by ultrasonography in patients who underwent Ultrasonography-Auscultation-Capnography. True negative results were found in four patients, while 2 false positives and 1 false negative were detected.

In the second group, the sensitivity of ultrasonography was 98.3% (95% CI = 91.06-99.96), Specificity was 66.7% (95% CI = 22.28 - 95.67%), PPV was 96.72% (88.65 - 99.60%), NPV was 80% (28.36-99.49%), Test Validity was 95.4%, Positive Likelihood was 2.95 (0.95-9.15), Negative Likelihood was 0.03 (0.00-0.19).

In the second group, Sensitivity was 100%, Specificity was 100%, PPV was 100%, NPV was 100% in tube location verification when auscultation was added to USG.

Sensitivity (100%) and Specificity (100%) of auscultation were detected, and although the Sensitivity (98.3%) and Specificity (66.7%) of USG were higher, no statistical difference was found between them ( $p > 0.05$ ).

## Discussion

The usability of ultrasonography in the emergency department has increased in recent years, and in our study, in intubation; It has been determined that ultrasonography has high sensitivity and specificity in terms of speed, accuracy and efficiency during the verification process of the endotracheal tube. Early recognition of incorrect intubation in the emergency department is of great importance in emergency airway management in terms of mortality and morbidity. There is no ideal verification method [10].

In the study by Abbasi et al., ultrasonography was performed transversely from the suprasternal notch superior to confirm the position of the intubation tube, the study lasted for about ten months in the emergency department, and the sensitivity of ultrasonography was 98% (95% CI=88.8-99.9%), the specificity was 95% in sixty patients. (95% CI=51.6-100%), positive predictive value 100% (95% CI= 91.5-100%), negative predictive value 85.7% (95% CI= 42-99.2%) [10]. Sensitivity, specificity, positive predictive and negative predictive values were found to be similar to the values in our study.

In the prospective randomized study conducted by Bunyamin Muslu et al. [14], 150 patients to be operated on in the anesthesia clinic were included, of which 75 patients were esophageal and 75 patients were tracheal intubation with direct laryngoscope. As a result, Sensitivity was 100% (95% CI, 84%-100%) and specificity was 100% (95% CI, 84%-100%) on ultrasonography. In our study, the duration of ultrasonography was found to be less than 6 seconds, and the sensitivity and specificity rates were found to be similar to each other. It

was thought that the fact that the aforementioned study was conducted under elective conditions may have affected the sensitivity and specificity. Our own study was conducted in a more dynamic and unstable environment, and it is possible that physical factors may affect the efficiency and speed of intubation confirmation.

In the study of Caner et al. [15], 64 tracheal intubations and 5 esophageal were detected by looking at the sliding movements in the lungs. Sensitivity, specificity, positive predictive value, negative predictive value of transtracheal ultrasonography were 96.9% (95% CI 89.2-99.6%), 80% (95% CI 28.4-99.5%), 98.4 % (95% CI 91.4-100%), 66.7% (95% CI 18.7-96.9%), respectively. In our study, the tube location was tried to be confirmed by looking at the superior suprasternal notch and the gliding movements in the lung, and the sensitivity, specificity, positive predictive value, and negative predictive values of the USGs performed by looking at the gliding movements in both the transtracheal and lung were found to be similar.

## Limitations

Ultrasonography is an experience-based method; Even though the clinicians included in the study have received ultrasonography training, there is a potential for these differences to affect the outcome of the study, as there are differences between individuals.

## Conclusion

Considering similar studies, the study provided an adequate number of patients. False intubation was detected in 11 (8.5%) of 130 patients. Although ultrasonography was less effective than auscultation, there was no statistically significant difference and ultrasonography application was faster.

Although it has 100% efficiency (with high sensitivity and specificity) in our study, there is a possibility of false negative or false positive results when the auscultation method is used alone in the verification of the location of the intubation tube in places with high potential to create a dynamic, noisy and chaotic environment such as the emergency room. In order to prevent this situation, it was concluded that the combination of USG and auscultation would be a more appropriate method. In this study, the results of transtracheal USG and the results of USG in the detection of sliding movements in the lung were found to be similar to each other. In a situation where ETT needs to be placed during CPR, Transteakel USG is more advantageous than lung USG during CPR, as it does not affect the CPR application area.

In addition, it was concluded that transtracheal USG can identify false intubation earlier and more effectively in emergency departments, since it detects transtracheal passage earlier than other methods in confirming the endotracheal tube location. USG can be applied in emergency practice as an aid to auscultation routinely used because it is easy to use, low cost and does not have harmful aspects such as radiation.

## Scientific Responsibility Statement

*The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.*

## Animal and human rights statement

*All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with*

the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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**Conflict of interest**

None of the authors received any type of financial support that could be considered potential conflict of interest regarding the manuscript or its submission.

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